GRID INTERFACING PV CONTROLLED MOTOR WITH ENERGY STORAGE

[1] P.Sowjanya, [2] M.V.Ramesh
[1] PG Scholar, [2] Associate Professor
[1,2]Deparatment of Electrical and Electronics Engineering,
[1,2]Prasad. V. Potluri Siddhartha Institute of Technology, Vijayawada,

Abstract: Solar energy is an abundant renewable source, which is expected to play an increasing role in the future for distributed generation. In this paper, a grid-connected system includes an integrated battery solution that is prepared in PSCAD. A simple control method capable of operating the solar PV array at its peak power using a common 3- phase voltage source converter is proposed for motor control. The speed of the motor is controlled through the optimum power of solar PV array. The utility grid is utilized as a secondary power source and total load demand is shared by photovoltaic array and grid. The sum of power shared by each source is controlled through a power factor corrected boost converter. Battery is connecting to the system in order to prevent voltage fluctuations, and to eliminate the power mismatch between PV power generation, motor and load demand. The performance of the system is developed and implemented using the PSCAD/EMTDC Software.

***IndexTerms* - Solar photovoltaic (PV) array, Maximum power point tracking (MPPT), Voltage source converter (VSC), Battery energy storage, AC motor**.

I. INTRODUCTION

The huge majority of the individuals know about non-renewable power sources. Sun energy has moved towards attractive famous because of their economic advantages. By on battery backup, Solar Energy can even give electricity 24x7, even on shady days and during the night [1]. This is well utilized with grid system with continuously Power supply. It has more advantages balanced with other types of energy like fossils fuels and oil stores. It is an elective which is guarantee and expected to fulfill the high energy demand.

The electric grid is an infinite amount of energy supply. In order to match between grid and distributed generation, and make best use of distributed generation in economy, the scholars put forward the concept of micro grid [2]. Micro grids allow generation to be located near load centers with better management and control mechanism to allow active distribution at a higher reliability. So as to discover an appropriate model of distributed PV system it is required to think about the behavior of an individual PV module to find how it works in the grid [4].

In a grid-tied PV system, distribution lines are a backup power source. A Battery Energy Storage System (BESS) will be helpful not only on a daily saving but as well as to reducing the PV output power fluctuations. Designing of PV array includes battery charging losses, load demand, discharge rate, battery size, and storage temperature. Climatic conditions, lower solar irradiation and higher temperatures are known causes for lower energy efficiency production. However, there is an on-going investigation relating to voltage control of a PV array with maximum power point tracking (MPPT) and battery storage [11]. The MPPT algorithm supports sustainable efficiency by dynamically adjusting the voltage to make power optimization [12].

Two important aspects that should be considered in designing the energy management and control in a micro grid are (i) generation-load power balance (ii) state of charge (SOC) of the battery.

An efficient motor drastically minimizes the number of solar modules for a given power demand and hence its capital cost. Permanent Magnet Synchronous Motors (PMSM) are similar to Brushless DC motors (BLDC). PMSM are rotating electrical machines that include a wound stator and permanent magnet rotors that offer sinusoidal flux distribution in the air gap, making the back EMF inform a sinusoidal form. The construction of the stator and rotor can offer lower rotor inertia and high power efficiency and reduces the motor size.

In this paper, a complete grid interfacing PV controlled motor with energy storage system PSCAD/EMTDC model is presented and MPPT modeling based on the incremental conductance algorithm. Different power electronic converters can be utilized to promise that PV systems are managed for maximum outputs with changes in both ecological and electrical parameters. The major contribution of this paper is to control the speed of the motor and energy management control for a grid connected PV system in PSCAD/EMTDC software.

Section II describes the system overview. Section III presents design of proposed system. Section IV presents Control algorithm. Section results V describes results for voltage output of the grid connected PV solar system and battery under various operating conditions. Section VI finally concludes the paper.

II. SYSTEM OVERVIEW

The block diagram representation of grid interfacing PV controlled motor with energy storage is presented in fig-1. The solar PV array with MPPT can be achieved by IC algorithm which is fed to the boost converter. Based on the reference power generated by the maximum power point tracker (MPPT) the boost converter adjusts the dc link current. Buck-boost topology is used for energy management control. The 3-phase voltage source converter (VSC) controls the dc voltage and tries to maintain it its reference value. The DC link capacitor is connected to a voltage source converter (VSC) which is responsible for bidirectional power flow between grid and load.

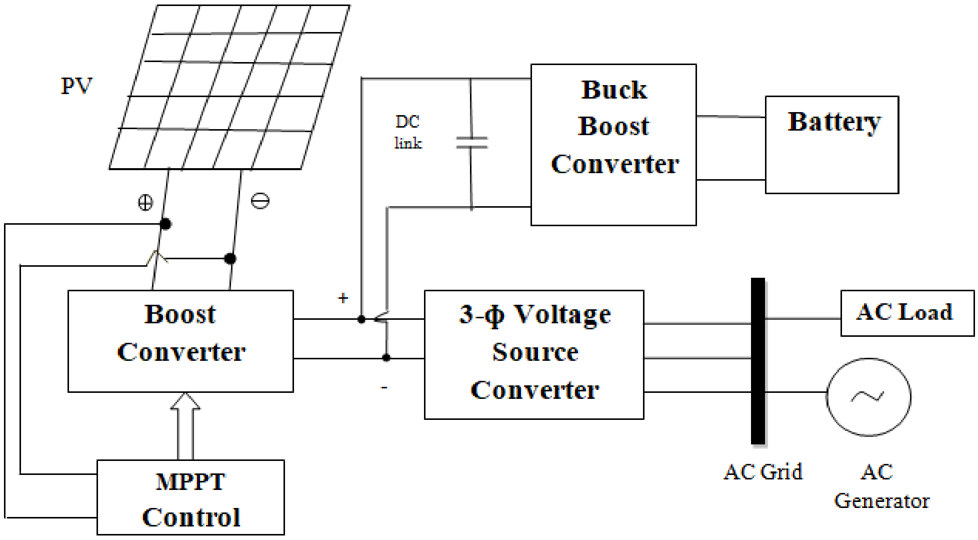

Fig-1: Block Diagram for Proposed System

The proposed system is operated based on two conditions. First one is when grid and battery is feeding the load. During night, when solar radiation is not available the grid and battery feed the load. Second one is when both the grid and solar PV array are feeding the load. When solar radiation is not enough to operate the load at rated speed, the required partial power is fed from the grid. During two conditions, the utility grid acts as a source. The speed of the load is proportional to the intensity of solar radiation.

III. DESIGN OF THE SYSTEM

Modeling of each of the individual components has been described in the following sections.

3.1 Solar Photovoltaic Array:

The system consists of a 4 KW SPV array made up of 1 module in parallel and 5 modules in series. The cells are configured to produce an open circuit voltage of 310V with a short circuit current of 14.4A. The maximum irradiance is $1000W/m^2$ and ambient temperature is to be as 25^0C , which turned into the standard value for the area of the given irradiance.

3.2 DC-DC Boost Converter:

The boost converter forms the essential part of the MPPT controller by providing a control according to the reference voltage generated by the MPPT algorithm. The MPPT controller continuously follows the system operating point and provides the reference voltage which is compared with the actual voltage available at the PV array terminals. The error is applied to PI regulator which generates a controlling signal. Now, the variation in the duty cycle changes the output voltage and it is always greater than the input voltage. The Duty cycle is given as

$$D= (1-Vin/Vout) \text{ ------------------- } (1)$$

The DC-DC boost converter topology consists of an inductor, switch and a diode. The boost converter parameters need to be evaluated to design the desired configuration converter. Therefore, the design parameters are as follows

$$L= V_{in} DT / \Delta I \text{------------------- } (2)$$

Where Vin =392V is the input voltage. The duty cycle D=0.6, T is the time period and ΔI is the inductor ripple current. ΔI is taken as 20% of the input current. The switching frequency f_{sw} is 20 kHz. The value of the inductance L is 0.6 mH.

3.3 Battery Energy Storage

A battery of 120A*hr capacity is provided at the DC link of the VSC. The rating has been chosen primarily keeping in mind that the battery storage could provide 2 kW for running continuously for a maximum of 6 hours that effectively covers the lean period of PV array generation when the power deficit needs to be handled. The voltage at the terminal of the battery is given by the following equation as

$$V_b \geq (\sqrt{2/3}\,) V_{LL} \text{ ----------------- } (3)$$

Where VLL =400V is the line rms voltage.

IV. CONTROL ALGORITHM

The efficient operation of the proposed system depends upon the following controllers as discussed below.

4.1 Maximum Power Point Tracking:

According to maximum power point theorem, output power of any circuit can be maximize by adjusting source impedance equal to the load impedance, so the MPPT algorithm is equivalent to the problem of impedance matching.

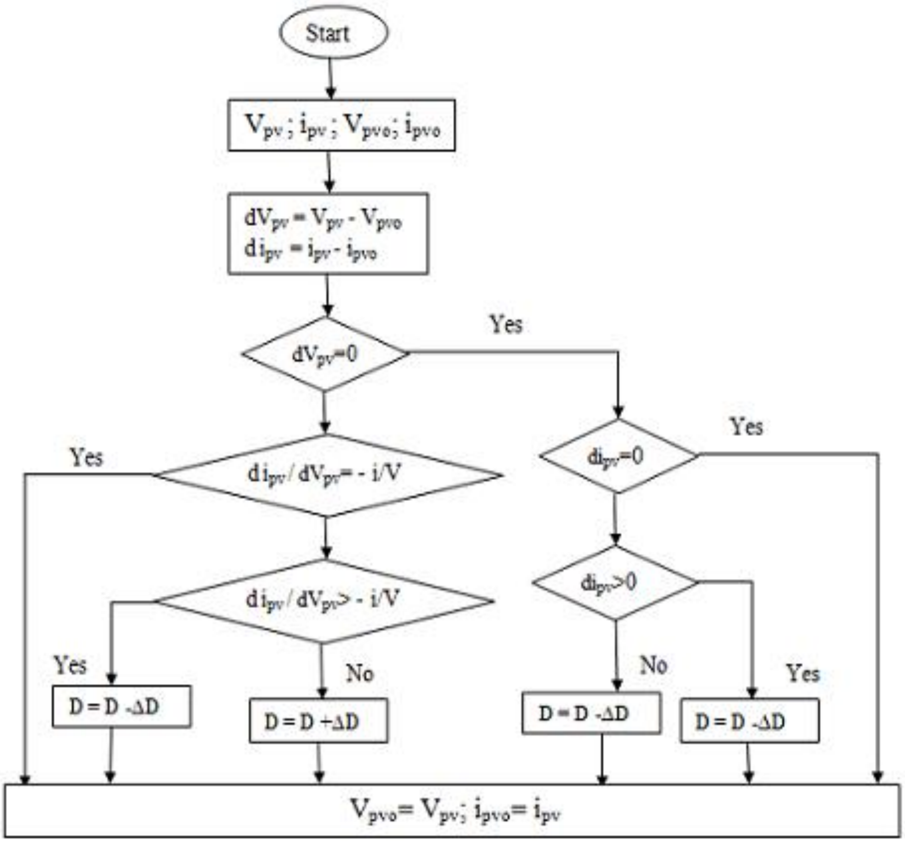

Fig -2: Incremental Conductance (MPPT) Algorithm

The maximum power point tracking (MPPT) algorithm is intended to extract the maximum available power from the SPV array under different operating conditions. The incremental conductance (IC) method is applied on account of the fact that it can fast track the maximum power even under continuously varying irradiance and temperature conditions. The IC algorithm operates to find the actual operating point by comparing the dI/dV with –I/V. This algorithm is inclusive as it operates to provide the maximum power independent of the panel characteristics, speed of convergence, easier to implement and the efficiency under steady state and dynamic conditions. The behavior of algorithm according to the following equations as,

$$\frac{dp}{dv} = 0 \text{ for } V_{mp} = V_{pv}; \frac{dp}{dv} > 0 \text{ for } V < V_{mp}; \frac{dp}{dv} < 0 \text{ for } V > V_{mp} \quad \text{---------------} \ (4)$$

This controller adjusts the PV array terminal voltage to the maximum power point voltage based upon the instantaneous and incremental conductance values.

V. RESULTS AND DISCUSSION

Depending upon the designed micro grid system comprising of SPV array, AC generator and BES. The system is analyzed with its operation under three phase AC motor .The results show that the system effectively controls the power flow and reactive power compensation. The system voltage and frequency is maintained stable under different loading conditions.

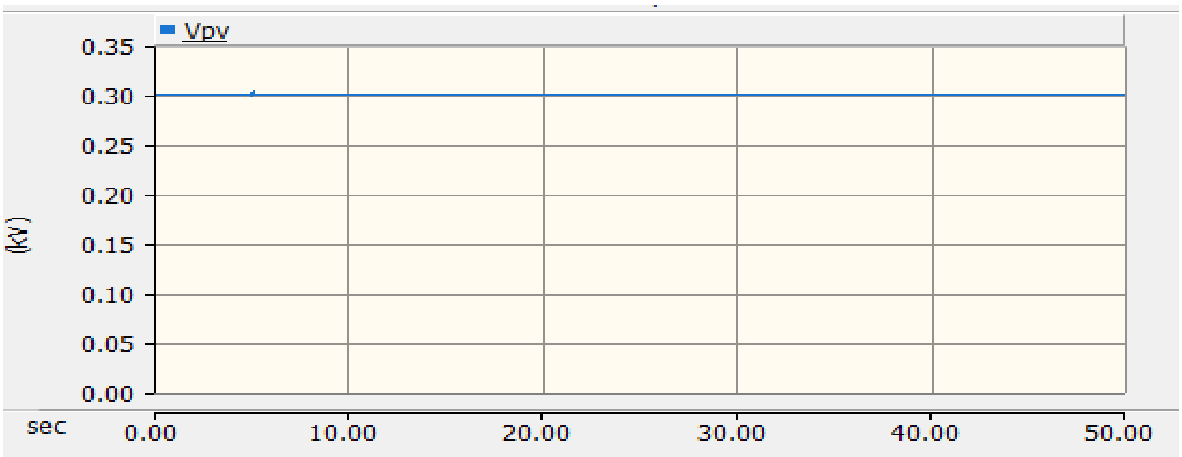

Fig-3: SPV Array output Voltage

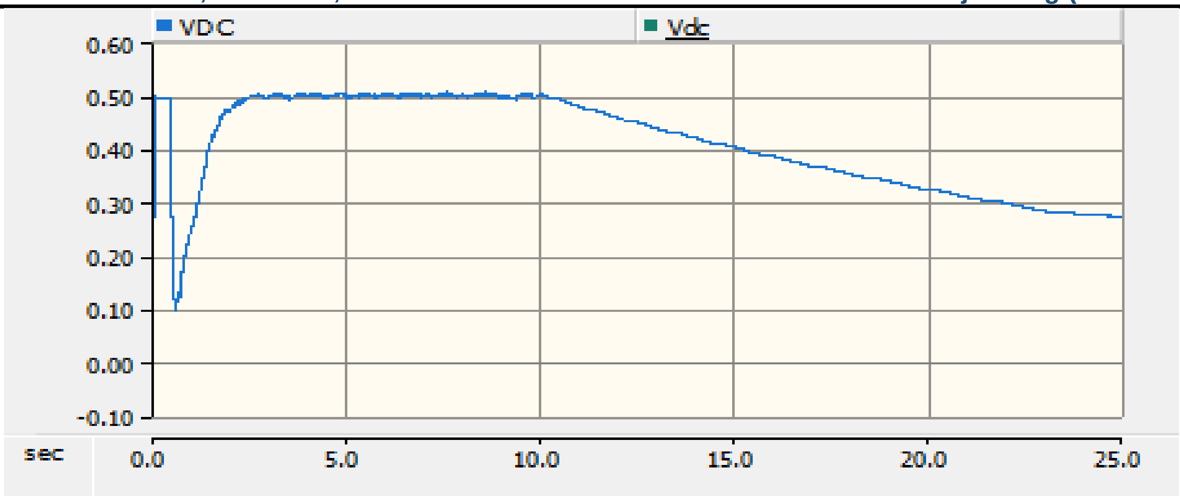

Fig-4: DC output Voltage

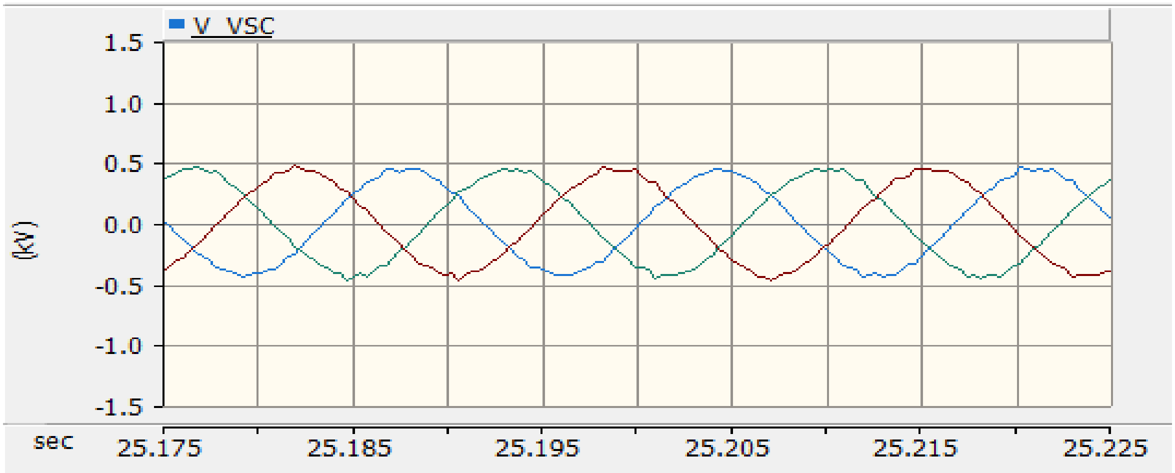

Fig-5: VSC output Voltage

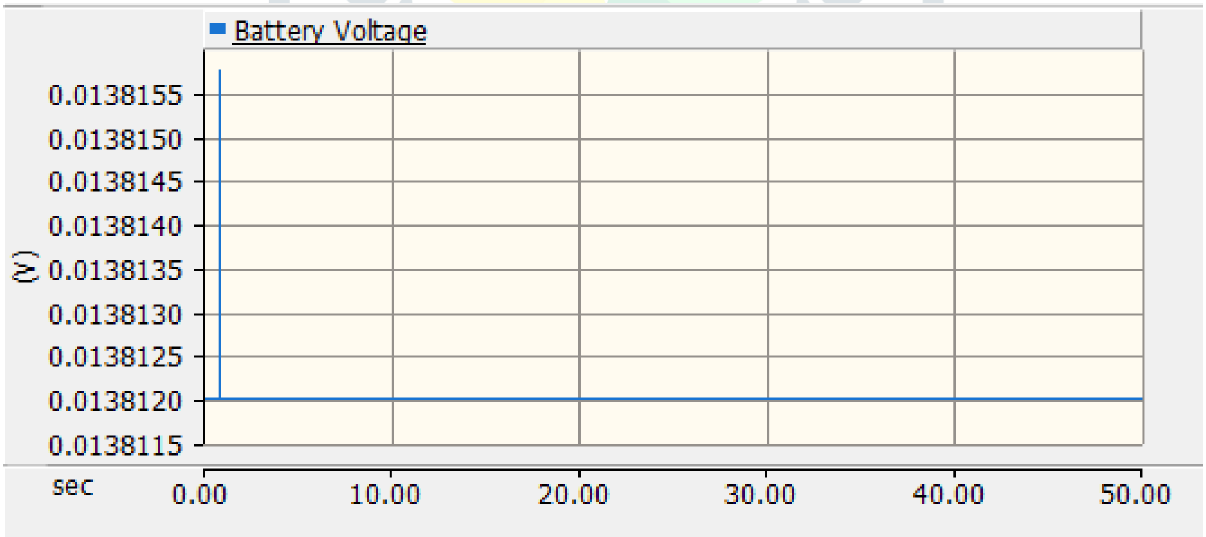

Fig-6: Battery output Voltage

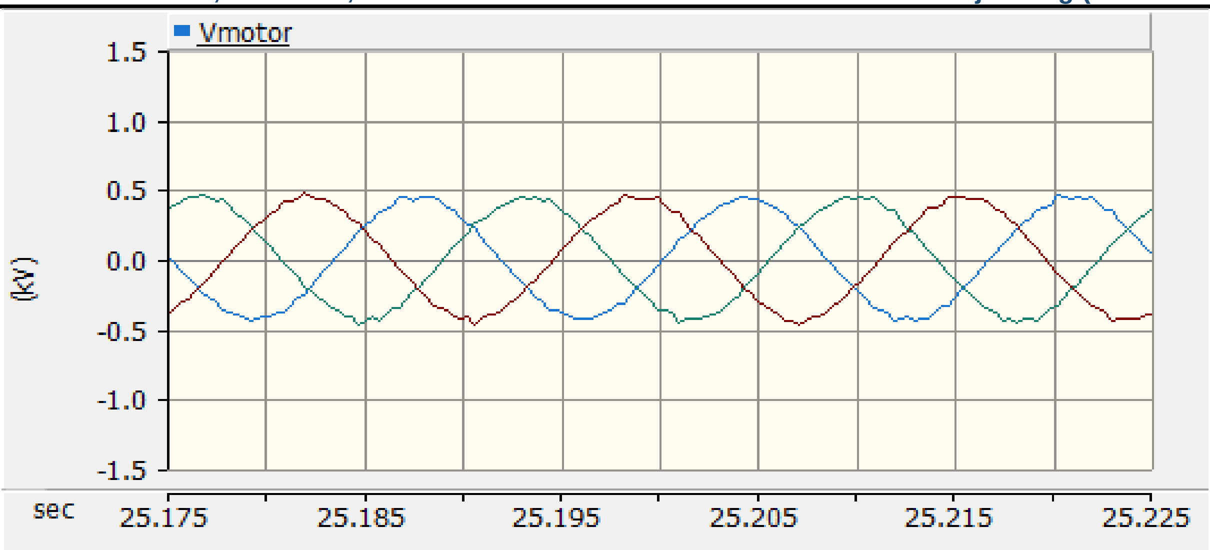

Fig-7: AC Motor output Voltage

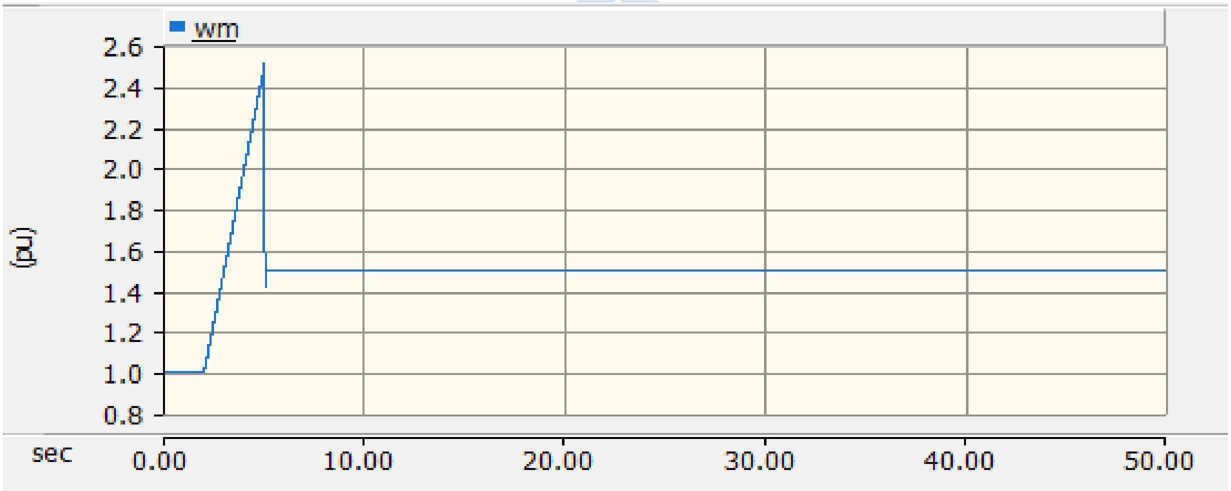

Fig-8: Speed of the AC Motor

VI. CONCLUSION

The performance of speed of the motor and energy management control for a grid connected PV system has been demonstrated in detail. It has shown that it essentially coordinates the power within the distributed sources. The SPV array has been controlled to operate at MPP using the incremental conductance based MPPT controller. The AC generator and BES have organized the power flow as per requirements within the system and provided load balancing. It has also allowed the operation of the micro grid system by handling the SPV power deficit. The frequency of the system has been maintained. The system has performed satisfactorily as verified by the obtained simulation results.

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