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Improvement of Power Quality in Renewable Energy Integrated Microgrid System Using CMBC

Dr. P.Sankar Babu[1], K.Meenendranath Reddy[2], S.Sneha Madhuri[2]

[1]Professor, Department of EEE, SVREC
[2]Assistant Professor, Department of EEE, SVREC

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ABSTRACT

The use of hybrid microgrid systems based on renewable energy sources (RES) is the most cost-effective way to solve the power supply problem in distant places that are far from grids. In this paper, describes the integration of a microgrid with photovoltaic generation, as well as the intelligent capability to feed generator active power and compensate reactive power, load balancing, and harmonic reduction. The efficiency is also improving, and the power factor is being brought closer to unity by employing the maximum power point technique. The current mode boost converter (CMBC) control algorithm is proposed for effective control and stabilization of battery converters by introducing, (i) virtual resistance (VR) in the outer loop known as outer loop virtual resistance control (OLVRC) and (ii) intermediate loop known as inner loop virtual resistance control (ILVRC).

A Battery Energy Storage System (BESS) is used to balance power between PV generation and grid utility. Grid integration of photovoltaic (PV)/Battery hybrid energy conversion system includes, i) MPPT tracking performance of high gain integrated cascaded boost (HGICB) dc-dc Converter with quadratic gain and less current ripple, (ii) battery converter tight voltage regulation capability, and (iii) multi-functional features of micro grid-side bidirectional voltage source converter. A model of this hybrid system is created in the MATLAB/SIMULINK environment to evaluate the dynamic performance of the battery converter.

KEYWORDS – Microgrid, PV System, BESS, DC-DC Converter, CMBC.

I.INTRODUCTION

Electricity demand has increased dramatically over the last few decades, necessitating more penetration from producing units and more efficient power grid operation. Higher living standards, population increase, pollution, and the depletion of conventional energy resources such as fossil fuels (coal, petroleum, natural gas, and so on) are increasing the crisis. Fossil fuels have their own drawbacks, such as CO2, NOx, and SOx emissions, which contribute to pollution and global warming. In today's power generation, the main disadvantage of central generating facilities is their inefficiency due to poor waste heat recovery and line losses. a novel concept of microgrid - a small grouping of energy sources and loads that can meet local demand while also helping to improve system efficiency Excess or deficit generation in a microgrid can be handled through energy and power flow management. The basic feature of a microgrid is that it is connected to the utility grid at a single point of connection and can be unplugged whenever an abnormal condition in the main grid occurs. Because the microgrid may function in Island mode in the event of an unanticipated loss of central generation or a transmission line fault, it assures continuous power supply to essential loads such as hospitals, military applications, banking sectors, and security sectors, among others. It improves overall system dependability and prevents blackouts.

There are numerous DC-DC converter topologies available to track the MPP in a PV generating system. The cascade connection of traditional converters allows for greater conversion ratios. One of the primary benefits of these converters is their high gain and minimal current ripple. However, because of power losses in the switching devices, the total efficiency of this system may become low if the number of stages is significant. There is also a quadratic converter design that uses a single switch and achieves quadratic gain. A high gain integrated cascaded boost converter with n-converters coupled in cascade via a single active switch is an appealing converter topology. When compared to a typical cascade boost converter, the instability produced by the cascade structure is avoided. This type of converter should only be used when the number of stages required is not too large; otherwise, the efficiency will be decreased.

The principle of microgrid not only reduces the number of reverse conversions in a single AC or DC grid, but it also simplifies power system connections to variable renewable AC and DC sources and loads. Micro-grid power converters are classed as I grid-feeding, (ii) grid-supporting, or (iii) grid-forming. Many control systems for controlling G-VSCs in microgrid applications have been published in the literature, including synchronous reference theory, power balancing theory, and direct current vector control. These techniques necessitate sophisticated coordinate transformations, which is time-consuming. In comparison to the previous control systems, the Instantaneous symmetrical component based control suggested in this paper for micro-grid applications is simple to formulate, avoids the interpretation of instantaneous reactive power, and does not require complex transformations.

2. SYSTEM MODELING

As indicated in the Fig.1, the proposed system is a PV/Battery hybrid system with the main grid linking to non-linear and unbalanced loads at the PCC. The photovoltaic system is represented as a set of nonlinear voltage sources. It shows a PV array connected to a dc-dc converter and a bidirectional battery converter that are coupled at the dc side of a G-VSC. The dc-dc converter attached to the PV array acts as an MPPT controller, and the battery converter is utilized to manage power flow between the dc and ac sides of the system.

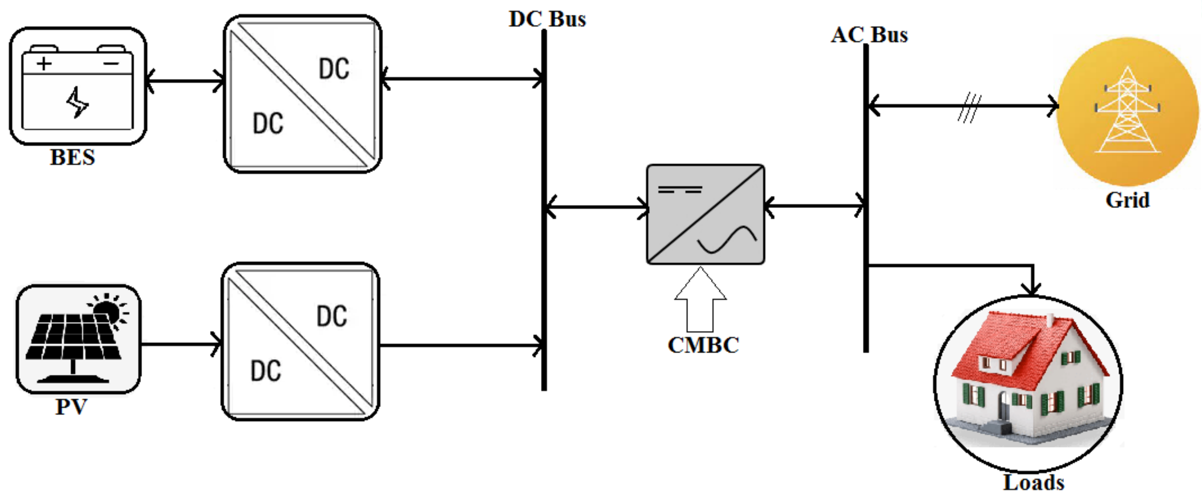

Fig.1: Proposed Hybrid Microgrid system

When the generated power from the solar cell is greater than the load current, the Battery Energy Storage System is used to store the energy and supply the energy to the load when the generated power is less than the load currents. As a result, supply reliability can be improved. To track the maximum power, the MPPT technique employs a perturbation and observation algorithm.

A. PV Modeling

Among the multiple renewable resources, PV is the finest alternative option for generating electricity from solar energy without emitting greenhouse gases, durability with non-rotating units, long lifespan, good efficiency, and low maintenance. The PV system is made up of cells that are connected in series to produce the desired voltage. By multiplying the terminal voltage by the output current, the PV plane of the final output voltage is computed. Figure depicts the created model of a PV panel.

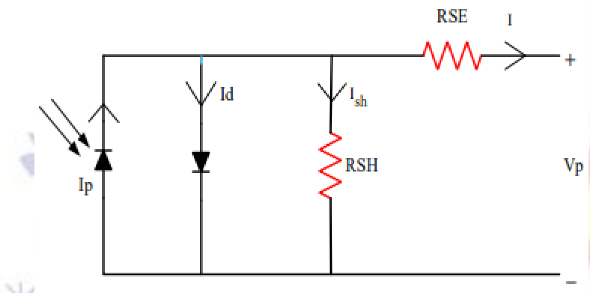

Fig.2: PV equivalent circuit.

Based on the Equations, the design PV panel current and terminal voltage is calculated.

$$I_P = I_{SC} - I_0\left\{\exp\left[\frac{Q}{akt}(V_P + I_P R_{SE}) - 1\right]\right\} - \frac{V_P + I_{SC} R_{SE}}{R_{SH}}$$

$$V_P = \frac{akt}{Q}\ln\left\{\frac{I_{SC}}{I_P} + 1\right\}$$

B. BESS Modeling

When the HRES produces insufficient power, the battery supplies the load demand. In the event of the system's required power consumption, the battery capacity was determined and considered using the reference autonomy day (AD) indicated below Equation.

$$B^{capacity} = \frac{Autonomyday \times P^L}{\eta^I \times \eta^B \times DOD}$$

Each switching period, the battery converter proceeds through two topological stages, and the power stage dynamics can be characterized by a set of state equations. As a result, the converter's average state space model is as follows:

$$\frac{di_L}{dt} = \frac{v_{c1}d_{(t)}}{L} - \frac{v_{c2}}{L} - \frac{(r_s + r_L)i_L}{L}$$

$$\frac{dv_{c1}}{dt} = \frac{v_{dc,Bus} - v_{c1}}{C_1 R1} - \frac{i_L d_{(t)}}{C_1}$$

$$\frac{dv_{c2}}{dt} = \frac{v_B - v_{c2}}{C_2 R2} - \frac{i_L}{C_2}$$

C. Control Strategy

If the AC side of the G-VSC has constant power appliances, their nature leads to negative incremental input-conductance, which causes instability of the dc-link voltage. The inherent negative admittance dynamics of their controlled conversion stages challenge the dc-link voltage management and stability on the microgrid generation side. This effect is amplified when the dc-link capacitance is lowered. As a result, in both circumstances, rapid and effective control and stability of the dc-link voltage is critical. Many approaches have been documented in the literature to handle this problem, including i) large DC link capacitance (ii) introducing passive resistances at various points in the DC LC filter (iii) loop cancellation methods.

Place one zero as high as feasible while not exceeding the converter's resonant frequency. To cancel the effects of output capacitor ESR, place one pole at the frequency of the output capacitor ESR. Adjust the compensator gain to balance stability margins and closed-loop performance. Another pole should be placed at the origin to increase the voltage loop's dc and low frequency gain.

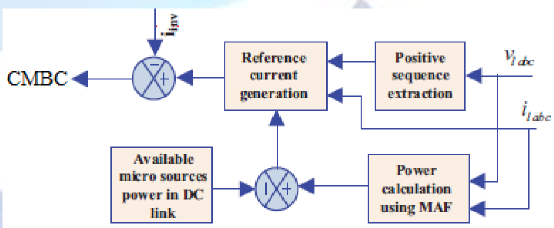

Fig.3: Proposed control for Microgrid.

3. SIMULATION RESULTS

The proposed control strategy for the PV battery hybrid system is developed in MATLAB/SIMULINK which consists of the PV solar array with Battery Energy

Storage System is connected to the grid using Voltage Source Converter for non linear load.

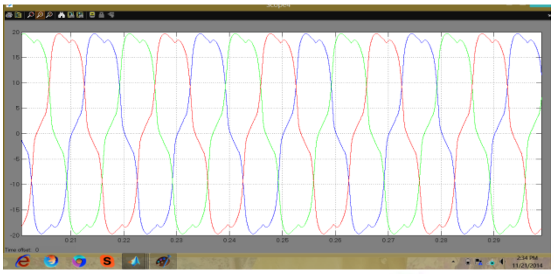

Fig (a): Load Current in Amps

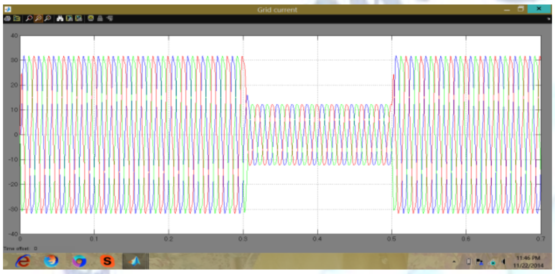

Fig (b): Grid Currents in Amps

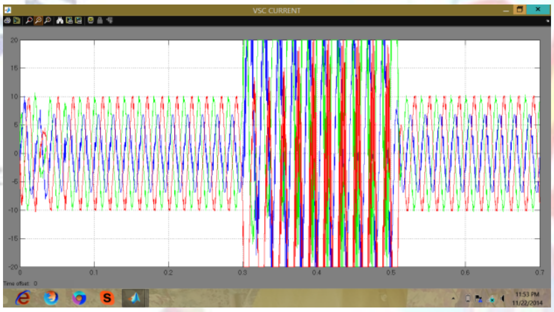

Fig (c): Micro Grid Voltage Source Converter Currents in Amps

Fig.4: Simulation results using proposed control approach for Micro-grid side VSC

When the insolation value is 200 then the maximum power obtained from the PV array is 2.5KW. The total dc load power 4.5KW out of that 2.5KW is supplied from the PV array and the remaining 2 KW is drawn from the grid through the bidirectional micro grid voltage source.

When the insolation value is changed to 1000 the maximum power obtained from the PV array is 12.5KW part of this power 4.5 KW is supplied to the DC load and remaining 8KW is supplied to the AC load through bidirectional micro grid voltage source converter.

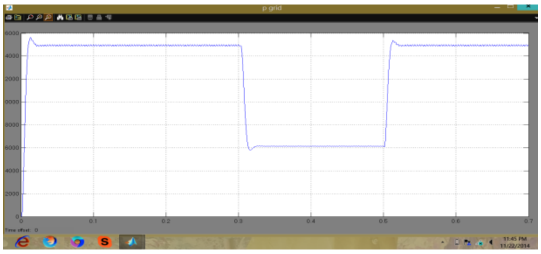

Fig (a): Active Power of Grid in Watts

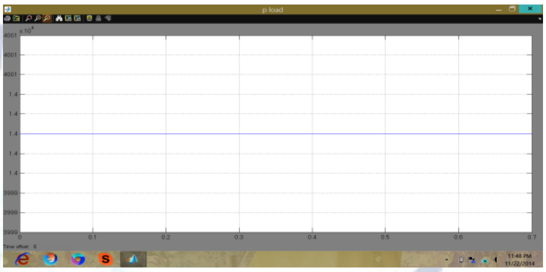

Fig (b): Active Power Ac Load

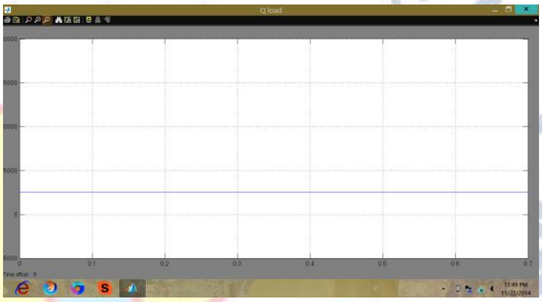

Fig (c): Reactive Power Ac Load

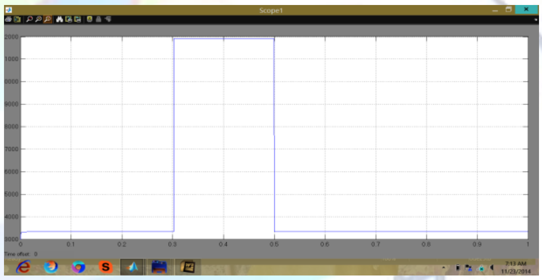

Fig (d): Active Power of PV Arrays

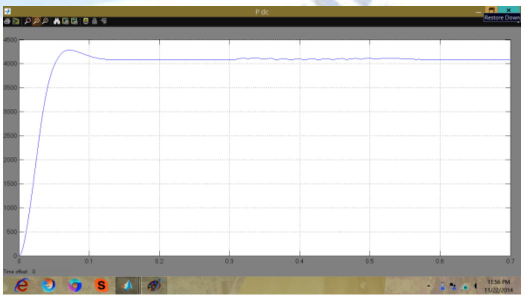

Fig (e): Active Power to Dc Load

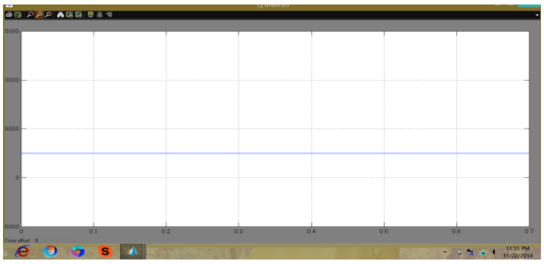

Fig (f): Inverter Reactive Power

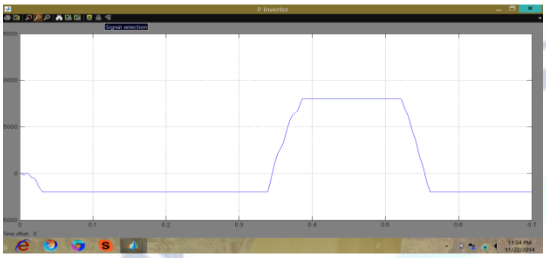

Fig (g): Inverter Active Power

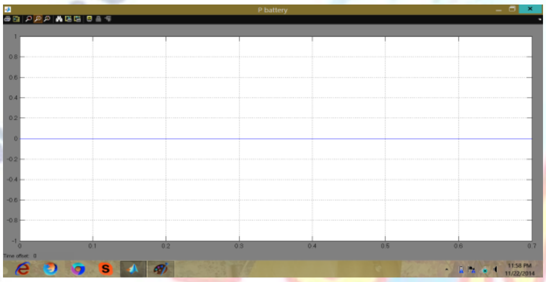

Fig (h): Battery Active Power

Fig.5: Real and Reactive Power flow waveforms of PV hybrid generating system.

Here observed that the power flows from ac side to dc link as shown in the Fig. 5. When insolation G = 1000 W/m^2, the maximum power available from PV arrays is 12.5 kW, part of this power (4.5 kW) is supplied to dc load and remaining power (8 kW) is supplied to the ac load through bidirectional μGVSC. In this case, the power flows from dc link to ac side. This shows the bidirectional power flow capability of μG-VSC. These dynamics of power flows can be seen from Fig. 5.

4.CONCLUSION

The performance of the PV/Battery hybrid system was examined using the modified instantaneous symmetrical components theory applied to the micro grid-Voltage Source Converter suggested in this study. This paper also includes a control technique for the battery converter to regulate the dc bus voltage. Under a variety of solar insolation and dc load situations. The micro grid-Voltage Source Converter can effectively inject generated active power into the grid, as well as compensates for reactive power and mitigates harmonics for unbalanced non-linear loads at the Point of Common Coupling. Under dynamic conditions, the system will function satisfactorily. The simulation results of an imbalanced nonlinear load will indicate that the micro grid-Voltage Source Converter can successfully inject generated power as well as power quality improvement features.

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